Console Access to the Beam Line Tuner

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Summary

The Beam Line Tuner uses the Acnet protocol to communicate with the Fermilab Control System. This paper documents which Acnet devices are available and how they are updated.

1. Introduction

This version is for both the Main Injector and Tevatron BLT. This update also includes upgrading the timing hardware.

1.1 CONSOLE INTERACTION

The Beam Line Tuner (BLT) interfaces with the Acnet protocol in three ways. Firstly, the BLT maintains a set of Acnet devices in which analysis results are stored. These devices are updated in the Virtual Instrument (VI) named BLT Main Acnet, after the data of an injection has been analyzed. Secondly, an Acnet console can directly control the BLT. This is handled by the Acnet subsection of VI called BLT Main in the User Interface Task. Thirdly, a console can set Acnet devices related to the operation of the BLT, e.g. a measurement specification.

1.2 FRONT-END ACNET DEVICE ACCESS POINTS

The locations in the front-end program that access the Acnet devices are kept to a minimum to simplify the program. The BLT initializes Acnet devices in the BLT Init VI and accesses devices in the Menu VIs: BLT Menu Spec and BLT Menu Pattern in a similar way as a console can do. Error messages are updated through the BLT Error VI. There are no other locations in the program that refer to Acnet devices.

1.3 LEGEND

To easily recognize the device names related to the Main Ring/Injector, device names start with I:BLT. For the Tevatron the devices start with T:BLT.

BLT = Beam Line Tuner

To make up the device names the following abbreviations are used:

Plane	H	= Horizontal
	V	= Vertical

3. Remote Control using Acnet

A console can issue a command to the LabVIEW program by writing a command array to the command register. A command consists of a command code and an array of command parameters, all part of one Acnet device. The front-end program processes the command as soon as it notices the command code is non-zero and resets the whole register to zero. Because of this you must set both in one setting. As this device is a vector device this is easily done with one Acnet setting. A result register indicates the status of the command execution.

3.1 ACNET COMMANDS

The first element of the command array represents the command to execute, the next nine are parameters for the command. The available commands are listed in table 1.

Index	Command	Param1	Param2	Param3	Param4	Param5
0	No Command	---	---			---
1	Trigger	---	---			---
2	Reset	---	---			---
3	Set Param	Param Id	Value			---
4	Toggle					
5	Load Data	Form	Type	Batch	Bunch/Turn	Mark

Table 1. Acnet commands to BLT.

BLTCOM Command register

1 device of 10 elements of type I32 , 40 bytes

The commands have the following meanings:

No Command: All values are zero, no command issued.
Trigger: Manual trigger to start sampling the position data.
Reset: Reset the hardware. This will take approximately a second.
Set Param: Set the parameter identified by *Param ID* to the value indicated by *Value*. Currently available: MeasSpec Param ID = 0 with Value = MeasSpec Index, this parameter would set the specification for the next data-acquisition. (The next spec index is set and the hardware is reset to load the next spec).
Toggle: Switch between local and remote operation.
Load Data: This command loads position data in to the data device. You can specify:

- Form tbt=0 or wave=1
- Type of data (scaled=0, filtered=1, raw=2)
- Batch number
- Bunch index (or turn in wave mode)
- Marker. This number will be copied in the BLTINF device so you can verify that it was your request that filled the buffers.

If you read out data in the TBT form, you will get data displayed for a particular bunch over all available turns. If you display data in wave format you will get the all the data in a batch for a specified turn. By requesting multiple turns you can create a waterfall plot of the batch positions. The data is only available for the last measurement. a new measurement will overwrite existing data.

Error: The Error command will replace any command issued that is not equal to the Initialize hardware command if the hardware is not initialized. The Error command will only update the command register and error message register with an appropriate message.

3.2 ACNET COMMAND RESULT

The Acnet Command Result register has eleven elements. The first element contains the result code, the following 10 are a copy of the issued command. The following codes are used for the result register's first element:

0 = Command Accepted
1 = Error

Commands are readout and queued for execution. At the time of this writing you can only find out whether the command was accepted or not. Further versions might enhance the workings of the command result register. However, if an error occurred due to the command or any other operation, the error will show up in the BLTMSG diagnostic message device.

BLTCMR Command Result

1 vector device of 11 elements of type I32, 44 bytes, read-only

Note. in the case that there is more than one application issuing commands, there can be a conflict. Another application could overwrite the command register before the front-end reads the value. Therefore, read out the result register to see if it was your command that was executed.

4. Measurement Specifications

The measurement specification (spec) determines when and how the data is taken. Through several Acnet devices the spec can be changed. There are up to 40 different specs. You can find out what the current spec is and what will be the next spec (unless you issue a command to load a different spec).

4.1 ACTIVE SPEC

The active or current spec number. This spec has been used to initialize the hardware.

BLTSPA Spec Active

1 device of type I16, 2 bytes , read-only

4.2 NEXT SPEC

The next spec number. This spec will be used after a measurement to initialize the hardware. This value is set by the current spec's next spec value or, through the command registers, by the console application or sequencer. You cannot set this directly because it would not reset the hardware immediately but wait until a measurement has been completed. Use the command register to set the new spec.

BLTSPN Spec Next

1 device of type I16, 2 bytes , read-only

4.3 THE SPECIFICATIONS

You can control many aspects of the measurement using the spec, see table 2. All 40 specs are stored in one Acnet device. To access the spec in a C program use the example c structure in list 1.

BLTSPC Operational Specs

*1 vector device of 40 (Specs) * 100 elements of type U8, 4000 bytes*

OFF SET	SIZE	ITEM
0	32	NAME of spec, 32 chars, string is null terminated
32	2	BEAMSYNC TYPE, ushort {PBS,ABS}
34	2	BEAMSYNC EVENT, ushort
36	4	BEAMSYNC DELAY, long (buckets)
40	2	TCLOCK EVENT, ushort
42	4	TCLOCK DELAY, long (microsec)
46	2	ACQUIRE MODE, ushort {TBT,Wave}
48	2	FIRST SAMPLE, ushort
50	2	SAVE, ushort {No Save, Save}
52	2	ANALYSIS, ushort {Off, Coupled, Uncoupled}
54	2	PATTERN, ushort
56	2	NEXT SPEC, ushort
58	2	REPEAT, ushort
60	2	HITSTRIG, ushort
62	2	BUFFER, ushort {0,9}
64	2	FILLER , ushort
66	2	TURNS
68	2	BATCH
70	2	CYCLE ushort {0,..,8}
72	2	CNT ushort {0,..,12}
74	26	FILLER
100	-	Total

Table 2. Definition of the Specification.

The entries of the spec have the following meanings:

Name: All values are zero, no command issued.

BEAMSYNC type: Select Proton BSYNC (0) or Pbar BSYNC (1).

BEAMSYNC event: Marker to use for pattern.

BEAMSYNC delay: Delay of pattern relative to marker (seconds??).

TCLOCK event: Event to start sampling.

TCLOCK delay: Delay (seconds) to event to start sampling

Acquire Mode: Acquire TBT data, 0 (normal operation) or Wave mode, 1 (diagnostics of e.g. kicker).

First Sample: Index of first sample to use for analysis. This can be different for protons or pbars depending on the location of the position detector (before or after the kicker/lambertson magnets)

Next spec: Next spec to be activate after this data taking (for Repeat times).

Repeat: Repeat this current spec *Repeat* times before going to the *Next spec*

Hitstrig: Number of hits (samples) per trigger. Normally equal to one. Only for diagnostics mode to look at bunches within a batch, see also *Batch*.

Buffer Index of (Acnet) buffer where the data should be stored. Value from 0 to 29

Filler1: Not used. (Execution mode).

Turns: Number of turns to measure. Note that one can specify more turns than the digitizer can handle. The front-end will reduce the number of turns to fit within the digitizers capabilities. (turns * (hits/trigger) * (triggers/pattern) must be less than 2^{16}-1)

Fill: Fill mode. This determines how the results will be filling the result acnet devices. For more details see section 7.5.
- First (value=0), In first bunch mode, only the first bunch of a batch will be analyzed, all other bunches defined by the Hits/trig will be ignored (but are taking up digitizer memory).
- All (value=1) All bunches in a batch are measured and analyzed, including the average.
- Pmean (value=2) Use the result of the mean position data from the multiple bunches in a batch.
- Rmean (value=3) Use the mean of the results of all bunches.
- Rmedian (value=4) Use the median of the results of all bunches.

Cycle: Reset event cycle, see table 3.

Count: Number of occurrences of trigger event required to start data-acquisition. Zero means the trigger event is ignored and data-acquisition starts on the specified cycle reset event after the trigger delay.

Filler: Array to take up unused space.

Value	Tev	Mi
0	x40	x20
1	x4D	x21
2	Any	x23
3	x3F	x29
4	xx	x2A
5	xx	x2B
6	xx	x2D
7	xx	x2E
8	xx	Any

Table 3. Cycle reset events

List 1 shows the definition of the Measurement specifications as a C structure. The total size of the structure is 100 bytes, unused space is occupied by a filler array.

```
typedef struct spec {
char                name[32];
unsigned short      bsync;
unsigned short      bsyncevent;
long                bsyncdelay;
unsigned short      tclockevent;
long                tclockdelay;
unsigned short      acquire;
unsigned short      1smple;
unsigned short      save;
unsigned short      analysis;
unsigned short      pattern;
unsigned short      nextspec;
unsigned short      repeat;
unsigned short      hitstrig;
unsigned short      buffer;
unsigned short      filler1;
unsigned short      turns;
unsigned short      fill;
unsigned short      cycle;
unsigned short      cnt;
unsigned short      filler2[13];
} spec;
```

List 1. Definition of the Spec as a C structure.

5. DATA TAGS

For each buffer a Tag is created to indentify the circumstances of the acquisition.

BLTTAG(tag) Vector of 10 Tags

One vector device of 2400 bytes of 10 tags of 240 bytes each.

```
offset           = buffer  * tagsize
{0,240,..,2160} ={0,..,9} *   240
```

A Tag contains information on the index of Measurement Specification that was active while taking the data, the Reset Cycle Event, the MDAT frame $56 or MI Cycle ID (MI only), and a time stamp (VAX compatible). Note that currently not all bytes of the Tag are used, see List 2.

```
typedef struct tag {
signed short      measspec_idx;
unsigned short    reset_cycle;
unsigned short    mdat_state;
unsigned long     time_stamp;
unsigned short    not_used[115];
} tag;
```

List 2. Definition of the Tag as a C structure.

6. DIAGNOSTICS

The diagnostic devices represent the state of the Beam Line Tuner front-end. The message includes errors on VXI access to the digitizer, timing, or multiplexer cards and access to files on disk or execution.

6.1 DIAGNOSTIC MESSAGE

Message string (C-style, null terminated)

BLTMSG Diagnostic MeSsaGe

1 device of 1000 elements of U8, 1000 bytes, read-only

6.2 STATE OF BLT

Currently, the state of the BLT is used only to indicate whether the system is initialized or not, see table 4.. The system will always reboot to an uninitialized mode . While the software is running in the uninitialized mode, and preferences have been read from the disk, none of the hardware will be accessed until the system is initialized.

BLTSTA State of BLT

1 device of type I32, 4 bytes, read-only

Value	Comment
-1	System uninitialized
0	System initialized
1	Error occurred, see message string

Table 4. Definition of status codes.

7. DATA READOUT

The date produced by the BLT is updated right after the analysis. Analyzed results can be stored into ten different buffers. There is only one location to store the position data. The buffer with index 0 is always updated with the latest data, the other indices are free to use by the users by defining the buffer in the Measurement Specification.

7.1 DATA UPDATE MECHANISM

It is possible to read out the Acnet devices while the data-acquisition program is updating the devices. This can lead to an inconsistent data set of part old data and part new data. To avoid this, a mechanism is implemented to determine if the data was updated while reading the devices. Before the program updates the devices it will write the current measurement number to the first element of a two element array. After the update, the program writes the measurement number to the second element, see figure 1.

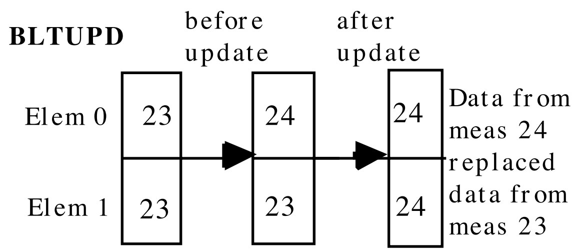

Figure 1. Marking the update of results.

Thus, a console reading out the analyzed data should do the following steps:

1) read the two elements of BLTUPD, if they are the same continue with step 2 otherwise, pause (about a second) and repeat step 1.

2) read devices containing results.

3) read the two elements of BLTUPD, if the values are equal to each other and equal to the readout in step 1, you have consistent data. Otherwise (element 0 is unequal to element 1 or doesn't match readout from step 1) data might have been partially updated and you will have to repeat the process and go back to step 1.

This method should not be used to synchronize read-outs from disk, you should instead check the status of the BLTCMR device. Also note that the data from two consecutive acquisitions not necessarily is stored in the same locations. If the data is saved to different buffers, there will be no data mixing.

BLTUPD Data results Freshness

1 device of type I32, 8 bytes, read-only

7.2 ANALYZED DATA

The analyzed data is stored in separate Acnet devices for each parameter of the analysis model. The parameters are: Tune, Phase, Amplitude, Damping, and Coupling for bunch with:

H = Horizontal proton,
V = Vertical Proton,
O = Horizontal pbar, and
E = Vertical pbar.

The Measurement Specification settings determine whether the data is stored as proton or pbar using the Beamsync type entry (0 for proton, 1 for pbar).

Each device is organized as seen in figure 2. There are 10 buffers of which each can hold results up to 36 bunches. The coupling indicates whether the time and frequency domain analysis judge that there is coupling (1 is most likely coupled, 0 is very unlikely coupled, typical ranges are from 0.25 to 0.75). The Fit Quality equals 1 for a good fit and 0 for a bad fit (Those are the only values currently possible).

BLT[H|V|0|E]TU(Bun*buf)	Tune
BLT[H|V|0|E]PH(Bun*buf)	Phase
BLT[H|V|0|E]AM(Bun*buf)	Amplitude
BLT[H|V|0|E]DM(Bun*buf)	Damping
BLT[H|V|0|E]CP(Bun*buf)	Coupling
BLT[H|V|0|E]FT(Bun*buf)	Fit Quality
BLT[H|V|0|E]TS(Bun*buf)	FFT Tune

*20 vector devices of 36*30 elements of type SGL, 4320 bytes/device , read-only*

```
offset      = bunch    + bunches_total *buffer
{0,..,1079} ={0,..,35} +           36*{0,..,29}
```

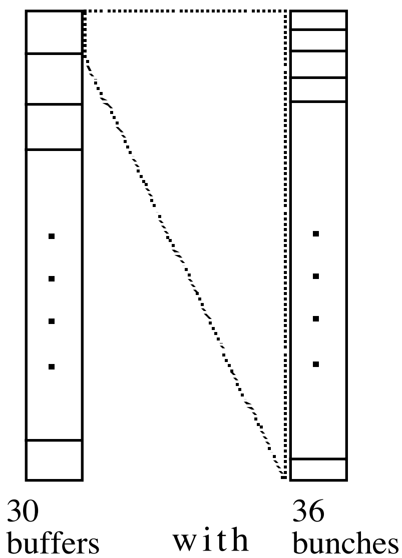

Figure 2. The organization of the analyzed data buffers.

7.4 POSITION DATA

Typically the systems acquires 1024 turns of position data to analyze the betatron oscillation. Note that the definition of bunch is given in the definition of the patterns (You can define the same physical bunch of particles, multiple bunch indexes). There are separate devices for the Horizontal and Vertical planes (H and V) and for the Raw and Filtered data (R and F). As the data size exceeds what can be addressed in a Acnet device, a special trick is used. The offset index within an Acnet request is multiplied by 1024 on the LabVIEW front-end. Thus requesting BLTHDR with offset of 1 and 4096 bytes will return 4096 bytes (1024 floats) at an offset of 1024 bytes. The offset multiplier is defined in the SSDN (see LabVIEW/Acnet documentation)See figure 3.

BLT[H|V]D[R|F](bunch*1024) Beam Position(measurement), bunch=0-35,

*4 vector devices of 1024*36 elements of type SGL, 147456 bytes/device, offset multiplied by 1024, read-only.*

offset = bunch {0,..,35}

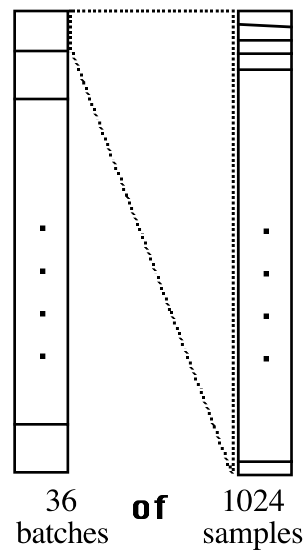

Figure 3. Organization of the beam position data.

BLT[H|V][PO|IN](pos) Beam Position/Intensity(measurement), pos=0-8191.

Four vector devices of 8192 elements of type SGL, 32768 bytes/device , read-only

offset = pos {0,…,8191}

When the position buffers are filled, the BLTINF device is updated, it will hold the size of the data in the buffers, e.g 1024, followed by the Marker value and then the tag of the data, see list 2. The full structure is listed in list 3.

```
typedef struct info {
long        size;
long        marker;
tag         datatag;
} info;
```

List 3. Definition of the Info as a C structure.

BLTINF() Beam Position Info,.

One device of 10 elements of type I32, 40 bytes/device , read-only

```
offset          = pos {0,…,8191}
```

Additional position data can be requested through the command register to be loaded in BLTDAT, see the section 3.1. Depending on the Form specified the data is indexed in bunches or in turns. The amount of data available depends on the pattern used in the measurement specification. For example, if only one batch with one bunch is specified then 64k samples are available for that one bunch (the full depth of the digitizer memory) of which the first 8192 samples can be accessed. This is 32768 bytes (4 byte floating point), the maximum per Acnet device. If eight batches were sampled with only one bunch per batch, then 8k samples would be available per batch, exactly the amount that fits in this buffer. Do remember that an Acnet message can only hold about 4000 bytes and you will need multiple requests with different offsets to read out the whole device

BLTDAT(bunch/turn) Beam Position(measurement), bunch/turn=0-8191.

One vector device of 8192 elements of type SGL, 32768 bytes/device , read-only

```
offset          = batch  * 256
{0,256,..,7936
} ={0,..,31} *  256
```

The BLT also generates power spectrum data for the filtered (first 512 samples out of 1024) and raw position data (second 512 samples). The offset field is multiplied by 1024 to allow Acnet addressing of the whole device.

BLT[H|V]SP(bunch) Beam Spectrum, bunch=0-35.

*One vector device of 1024*36 elements of type SGL, 147456 bytes/device, offset multiplied by 1024, read-only*

```
offset          = bunch     {0,..,35}
```

7.5 FILLING OF THE RESULT BUFFERS

The result buffers can be filled different ways. The front-end acquires the data based on pulses in the pattern and on how many samples must be taken per pulse. Each pulse is associated with a batch that contains one or more buckets. The batch will be sampled at the start of the pulse for hits/trig times at the sampling frequency, which is 53MHz for the V440. If using the other digitizers, only one sample per batch can be done. The analysis will also get an average position per batch. Results are also calculated for each plane. The front-end will thus collect data in 3 dimension: plane, batch, bunch. The bunch =0 is always filled with the results from the average position for the batch. When unfolded for one plane and with 2 pulses with 3 hits/trg the order of results is:

$B^1_{av}, B^1_1, B^1_2, B^1_3, B^2_{av}, B^2_1, B^2_2, B^2_3$ with B^N_M with $N = batch$ and $M = bunch$

With each batch is an associated bunch index number as defined in the pulse patterns. So B^1_M can be associated with bunch index 0 and B^1_M can be associated with bunch index 1. The pulse patterns can be defined from the front-end only.

These results will be put into the Acnet results devices according to the Fill parameter which should be set according to the whether the beam is coalesced or uncoalesced beam and how many results you want to have available:

1. Coalesced beam: The Fill parameter of the Measure Specifications is set to *first*. This means that B^1_1 will be put in the array index associated with B^1_M. The other results will be ignored.

2. Uncoalesced beam, average only. The Fill parameter must be set to Pmean, Rmean, Rmedian. or Pmean takes the average of the position data and then

analyzes the average position, Rmean analyzes all bunches and then averages the results, Rmedian analyzes all bunches and then takes the median value of the results. B^1_{Av} will be put in the array index associated with B^1_M. The other results will be ignored.

3. Uncoalsced beam, all results. The Fill parameter must be set to All. All values will be stored in the order: $B^1_{av}, B^1_1, B^1_2, .., B^1_M, .., B^N_{av}, B^N_1, B^N_2, .., B^N_M$, ignoring the associated bunch index.

The associated bunch index is modified by the BLTBUN Acnet device for use with coalesced beam. This device holds a bunch index offset for each of the 40 measurement specifications. The offset adds a delay to the pulse pattern such that it will shift a P1 pulse to location P2 on value of 1. On value of 1 it will shift a P1 to P3. The front-end knows the exact location of all coalesced bunches and will apply the correct bucket shift to the pattern. In addition, the associated bunch index is summed with the value of the BLTBUN to obtain the new index where to store the results. This mechanism is intended to be used during proton or pbar injection into the Tevatron while using the same Measurement Specification (one for proton, one for pbar) but shifting which bunch P1 to P36 to look at.

BLTBUN(Measpec) Bunch offset(Measpec), Measpec=0-39.

One vector device of 40 elements of type I32, 160 bytes/device , Write/read

```
offset       = Measpec   * 4
{0,1,..,156} = {0,..,39} * 4
```

APPENDIX A: The Device Table

1/13/2000 BLT Version 1.0 From Tev W. Blokland												
Device name	SSDN #	Read /Write	Vari-able type	Bytes / ele-ment	El-ments/device	Ini-tial value	Up-date rate	Unit	Unit	Long/Short	Nota-tion	Description
BLTUPD	0	R	I32	4	2	0	60	unit	bnch	short	dec	BLT Acnet Update Seq
BLTDAT	570	R	SGL	4	8191	0	1800	mm	mm	short	dec	BLT Position Data Buffer
BLTHDR	580	R	SGL	4	8191	0	1800	mm	mm	short	dec	BLT Hor TBT Raw
BLTVDR	581	R	SGL	4	8191	0	1800	mm	mm	short	dec	BLT Ver TBT Raw
BLTHDF	582	R	SGL	4	8191	0	1800	mm	mm	short	dec	BLT Hor TBT Filtered
BLTVDF	583	R	SGL	4	8191	0	1800	mm	mm	short	dec	BLT Ver TBT Filtered
BLTCOM	100	RW	I32	4	10	0	60	unit	unit	short	dec	BLT Command Register
BLTCMR	101	RW	I32	4	11	0	60	unit	unit	short	dec	BLT Command Result Reg
BLTREA	110	R	I16	2	1	0	60	unit	unit	short	dec	BLT Garanteed Readable
BLTSET	111	RW	I16	2	1	0	60	unit	unit	short	dec	BLT Garanteed Settable
BLTSPA	200	R	I16	2	1	0	60	unit	unit	short	dec	BLT Spec Active Index
BLTSPN	201	R	I16	2	1	0	60	unit	unit	short	dec	BLT Spec Next Index
BLTSPC	202	RW	U8	1	4000	0	600	unit	unit	short	dec	BLT Operational Specs
BLTSPF	203	RW	U8	1	4000	0	600	unit	unit	short	dec	BLT Inspection Specs
BLTTAG	300	R	I32	4	1800	0	600	unit	unit	short	dec	BLT Fly Tags
BLTBUF	304	R	I32	4	1	0	600	unit	unit	short	dec	BLT Last Savebuf
BLTSMP	305	R	I32	4	2	0	600	unit	unit	short	dec	BLT Last Num of samples
BLTSTA	350	R	I32	4	10	0	60	unit	unit	short	dec	BLT State
BLTMSG	351	R	STR	1	1024	No Msg	240	str	str	short	dec	BLT Diagnostic Message
BLTHTU	500	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Hor Prot Tune
BLTVTU	501	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Ver Prot Tune
BLTOTU	502	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Hor Pbar Tune
BLTETU	503	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Ver Pbar Tune
BLTHPH	504	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Hor Prot Phase
BLTVPH	505	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Ver Prot Phase
BLTOPH	506	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Hor Pbar Phase
BLTEPH	507	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Ver Pbar Phase
BLTHAM	508	R	SGL	4	1080	0	120	mm	mm	short	dec	BLT Hor Prot Amplitude
BLTVAM	509	R	SGL	4	1080	0	120	mm	mm	short	dec	BLT Ver Prot Amplitude
BLTOAM	510	R	SGL	4	1080	0	120	mm	mm	short	dec	BLT Hor Pbar Amplitude
BLTEAM	511	R	SGL	4	1080	0	120	mm	mm	short	dec	BLT Ver Pbar Amplitude
BLTHDM	512	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Hor Prot Damping
BLTVDM	513	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Ver Prot Damping
BLTODM	514	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Hor Pbar Damping
BLTEDM	515	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Ver Pbar Damping
BLTHCP	516	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Hor Prot Coupling
BLTVCP	517	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Ver Prot Coupling
BLTOCP	518	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Hor Pbar Coupling
BLTECP	519	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Ver Pbar Coupling
BLTHFT	516	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Hor Prot Fit Quality
BLTVFT	517	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Ver Prot Fit Quality
BLTOFT	518	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Hor Pbar Fit Quality
BLTEFT	519	R	SGL	4	1080	0	120	unit	unit	short	dec	BLT Ver Pbar Fit Quality
BLTLOG	800	R	STR	1	10000	No List	600	Str	Str	short	dec	BLT Log List
BLTATC	810	RW	U8	1	8800	0	600	None	None	short	dec	FW Pattern buffer
BLTATF	811	RW	U8	1	8800	0	600	None	None	short	dec	FW Pattern buffer file

BLTPAR	10	R	I16	2	2	0	120	unit	unit	short	dec	BLT Param Dimensions
BLTDIM	11	R	I16	2	3	0	120	unit	unit	short	dec	BLT Data Dimensions
BLTHSP	584	R	SGL	4	8191	0	600	unit	unit	short	dec	BLT Hor Spectrum
BLTVSP	585	R	SGL	4	8191	0	600	unit	unit	short	dec	BLT Ver Spectrum
BLTBAT	12	R	I16	2	50	0	600	unit	unit	short	dec	BLT Batch Indices
BLTSTU	100[8]	RW	I32	4	1	0	120	None	None	short	dec	BLT Set Spec Index
BLTCYC	202[1070]	RW	U16	2	1	0	120	None	None	short	dec	BLT Studies Cycle Reset
BLTTRG	202[1040]	RW	U16	2	1	0	120	None	None	short	dec	BLT Studies Trigger
BLTDEL	202[1042]	RW	SGL	4	1	0	120	usec	usec	long	dec	BLT Studies Trig Delay
BLTCNT	202[1072]	RW	U16	2	1	0	120	None	None	short	dec	BLT Studies Trig Count
BLTBKT	202[1036]	RW	SGL	4	1	0	120	bkts	bkts	long	dec	BLT Studies Bucket Delay

Table A1. The device table for the Main Injector Beam Line Tuner.